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BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

INTRODUCTORY STUDY

of the

PARASITES, PREDATORS, AND SOME OTHER ASSOCIATED INSECTS

of the

MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

By
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Coeur d'Alene, Idaho
January 24, 1929

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Respectfully Submitted

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PROLUSION

In an attempt to determine the relationships, significances, and life histories of the more common subcortical insects associated with Dendroctonus monticolae Hopk. (mountain pine beetle) in lodgepole pine, a study of the subject was begun the first of August, 1928, at Sula, Montana, a center of an heavy epidemic of this beetle. Insects on which intensive observations were made are: Coeloides sp., Medeterus sp., Lonchaea viridana Meigen. A list of less common insects, concerning which but little is known, follows the Lonchaea report.

A study of this kind for this region is of importance, since to date no one knows the complete life histories of any of the insects listed, and though knowing that some are beneficial as parasites and predators, there are several insects that we think are scavengers or predators, but about which we really know nothing; nor do we know how great a part those that are known to be beneficial actually play as controlling factors. If it is possible to determine their life cycles we may be able to direct control measures in such a manner that the beneficial insects will be favored in their work. It is to accomplish this end that this study was instituted.

The following data are by no means final; many points in the seasonal history and habits are obscure, but the life cycles, however, are given complete whenever possible, even though they have required conjectures.

COELOIDES sp.

Order Hymenoptera, Family Braconidae

Of all the insects associated with Dendroctonus monticolae those that belong to the genus Coeloides are perhaps of greater importance in biological control of the beetle than any of the other investigated species.

A better idea of the characters of the species observed will be had by a study of the appended drawings, (Plate II, Figs. 6 and 7) than by a written description. There are, however, two types of this species which, though determined as identical, at first glance appear distinct. In one group the female has a reddish abdomen, in the other a black or nearly black abdomen. The female of the former type is generally larger and more robust than the female of the latter; in both groups the head and thorax are piceous.

Seasonal History

Adult

During May, June, and perhaps part of July, the adult Coeloides emerge from their cocoons in the larval galleries of trees attacked by D. monticolae two years previously. (Cf. chart). (1)

The females fly to trees attacked by beetles the preceding year and there crawl over the bark surface "sounding" with their antennae

(1) A careful study of the chart, bearing in mind the life history of D. monticolae, will help in keeping the relationships clear.

for the larvae beneath which are detected, in all likelihood, by the vibrations caused by the mandibles scraping against the tree tissues when feeding. The parasite does not employ entrance, air, nor exit holes, as a means of getting closer to the larvae or finding better going for her ovipositor, nor in fact does the adult Coeloides ever see the beetle larva on which her egg is laid; nor would she, as experimentation has proved, lay her eggs on an exposed larva, however long the two remain together.

When a suitable host is found (no matter how it is accomplished) the parasite raises the end of her abdomen until the ovipositor is in a vertical position. She then adjusts herself until the tip of the terebra is over the selected larva, sometimes taking several minutes before she appears satisfied with her position, at other times but a second. Next a slight vertical vibration of the abdomen occurs as the ovipositor is worked in to the bark. When the female reaches the host she depresses the terebra suddenly, forcing it, perhaps, through the cuticula of the larva. If this is what happens, it is not, however, to lay the egg, since the egg is deposited on the surface of the larva, frequently even upon the head capsule, though the precise time that the egg is deposited could not be determined. The length of time required to penetrate the bark probably varies with its thickness, texture, and moisture content; twelve minutes was the shortest time observed, and fifty mimutes the longest. Immediately

after the sudden depression of the terebra mentioned above, the female withdraws it, usually wipes it off with her hind legs, and goes in search of another victim.

The victims selected appear to be the larger larvae, and there are strong indications that the parasite concentrates on the last or the last two instars. However, data at present are insufficient to warrant a positive statement in regard to this point. A parasitized beetle larva, usually within two days after the egg has been laid, becomes inactive (though they show the effect after 4 or 5 hours), i.e., when stimulated by some object such as forceps it either shows no signs of life or moves only slightly and ceases movement much sooner than a non-parasitized larva that has been stimulated. In other respects, except for a very slight darkening of the tissues, the parasitized larva does not differ from a non-parasitized one until a great deal of the larval fluids have been sucked out by the parasite, causing the cuticula to collapse. Whether the mummified condition is caused by the parasite piercing the larva and injecting a paralyzing fluid, or whether it is due to the mechanical effect of the puncture alone, has not been determined conclusively. Experimentation has demonstrated that piercing the cuticle of a beetle larva with a fine needle tends to produce the same effect as piercing with a Coeloides ovipositor; but the larva pierced by a needle frequently blackens, and in many cases shrivels, after a few days. On the whole the needle-pierced larvae do not remain

in a state of preservation as well as the Coeloides-pierced larvae. In performing the puncturing operation, it is necessary to shorten the Coeloides ovipositor, as the natural length terebra is too flexible to enable one to pierce the cuticula of the beetle with ease. That portion of the ovipositor remaining attached to the body is the part used in the operation, and on the tip of it there appears a globule of colorless liquid, but whether this fluid is the element that causes this better state of preservation among the Coeloides-pierced larvae has not yet been determined. Nevertheless it is strongly believed that such is the case, since it is known that certain other hymenopterous insects (2) embalm the prey on which they lay their eggs.

Adult Coeloides collected in the field have been kept alive in captivity from 16 to 32 days, but the average number of eggs laid by an individual each day has not been determined. Therefore, we have no idea of their fecundity.

Egg

The uniformly whitish egg is approximately 1 mm. in length (Plate I, Fig. 1) and hatches in the field laboratory 2 to 4 days after being laid. The shortest record is 46½ hours; the longest 100 hours. The maximum and minimum may be found to vary, however, with the season of the year and the daily temperatures. Records

(2) The Psammocharidae. Imms. p. 573
Comstock, p. 890

of eggs laid in the field and left in the tree under natural conditions were difficult to obtain, due to the fact that the bark had to be removed from over the larva on which the adult parasite was seen to work, in order to determine whether or not the egg was laid and upon which larva. Frequently examination has revealed no eggs. In that case the larvae in the adjacent area were collected to find out whether or not they would become mummified, but none ever did. Thus it seems likely that the adult may miss the larva with her ovipositor and not lay an egg; in any case it appears at times that no egg is laid, though the female may spend an half hour penetrating the bark. If an egg has been laid the bark square removed is replaced and held in position with a stout pin. However, when the square is next examined, staphylinids, Lasconotus, Laemophloeus, and Epuraea are usually found under it. If the beetle larva and parasite egg are present then, they will not be for long, for whichever species it is that removes them soon does a good job. Perhaps they all share in the work. That is one of the points to be investigated next season. Nevertheless, two records of egg periods secured in the field show that one egg hatched after 93 hours; the other after 95 hours had elapsed.

Larva

The larva (Plate I, Figs. 2 and 4) is approximately the same size and color as the egg from which it emerges, and the head, though the same color as the rest of the body, is easily distinguishable in

this stage. However, as the larva grows in size, the head becomes more and more retracted within the thorax. (Plate I, Fig. 4). The young parasite, though apodous, crawls about over the surface of the beetle larva, which by this time is thoroughly "mummified", until it finds a suitable spot to feed. They are found on any part of the beetle larva, except the head capsule on which they do not feed, occurring on the dorsal, ventral, and pleural regions, cephalad as well as caudad. The Coeloides larva has but vestigal mouth parts, of which the best developed are the mandibles (Plate I, Fig. 5) with which it apparently punctures the cuticle, sucking up the fluid that exudes therefrom. As soon as feeding begins the growth is rapid, especially in width; consequently, instead of being elongate with nearly parallel sides, it appears, after 8 or 10 days, more or less, swelled (Plate I, cf. Figs. 2 and 4), with the segmentation less distinct. As the parasite larva matures, small whitish "fat-bodies" develop beneath the cuticle. The earliest recorded appearance of these is three days after hatching, but this is unusually early. It is believed that the bodies are excretory in function as no exuviae were found for any of the larvae reared; nor probably, as is the case with most apocrita, does the mesenteron connect with the proctodaeum. When the larva is nearly mature the lipoid bodies, as the "fat-bodies" are tentatively called, assume a slight yellowish cast, as does the rest of the larva. Usually when this becomes marked the parasite larva, within a few days, ceases

feeding. It may spin a cocoon immediately, as is usually the case; or delay, for some as yet unknown cause, an indefinite period. The shortest recorded elapsed time from the time the egg was laid until a cocoon was spun is 15 days, but larvae under nearly identical conditions have not spun cocoons after 80 days, though no feeding has been done for the past 55 or 60 days.

By the first week in July a great majority of parasite larvae have spun cocoons. These may be divided into two groups: (1) those that are nearly white; and (2) those that are rather tan, but whether there is any significance in the two shades is as yet undetermined. The larvae probably remain as such until the following spring, then pupate to emerge during May and June.

The above is the general life history of the main generation of Coeloides. There is, however, an interesting variation called the early generation, of which little is known (cf. Chart 1 for relationship to main generation). It has been observed that Coeloides will parasitize a few D. monticolae larvae in the fall of the year of attack if part of the brood is well advanced. The parasite larvae then develop partially that season and may complete their development the next spring along with the larvae that have developed from the first eggs laid by the females of the main generation. After spinning their cocoons, which cannot be distinguished from the cocoons spun by the larvae of the main generation, they emerge in early July and August

when the brood of the main generation are still larvae within their cocoons. This accounts for that small percentage of Coeloides that were found to emerge in July and August from cocoons in the galleries of D. monticolae larvae in trees killed by the adult beetle the previous season.

That there are adult Coeloides present in August and September is accounted for not only, perhaps, by the length of life of those emerging in May, June, and July, but also by the fact that the imago does not confine its attack to the larvae of D. monticolae. It parasitizes as well sundry species of Ips, chiefly oregoni Hopk., probably because they are in greater abundance than the other species. Since Ips has several generations a year, the adult parasites have sufficient material to work upon after the D. monticolae brood has completed its larval development. Consequently Coeloides are probably parasitizing Ips oregoni the entire season, and it therefore follows they will most likely be emerging over a range of several months the following season. We may find, however, that though the parasites are working on the Ips over a period of several months, the adults all emerge in the spring at the same time, and it is only the adults of the early generation that carry on the work during August and September. There are many pros and cons for the above and several more possibilities that may arise, but they can all best be settled by further study.

Coeloides larvae have not, to date at least, been collected from Hylorgops larvae, nor was it possible to get the adult to parasitize them in the field laboratory. The same applies to Cerambycid larvae.

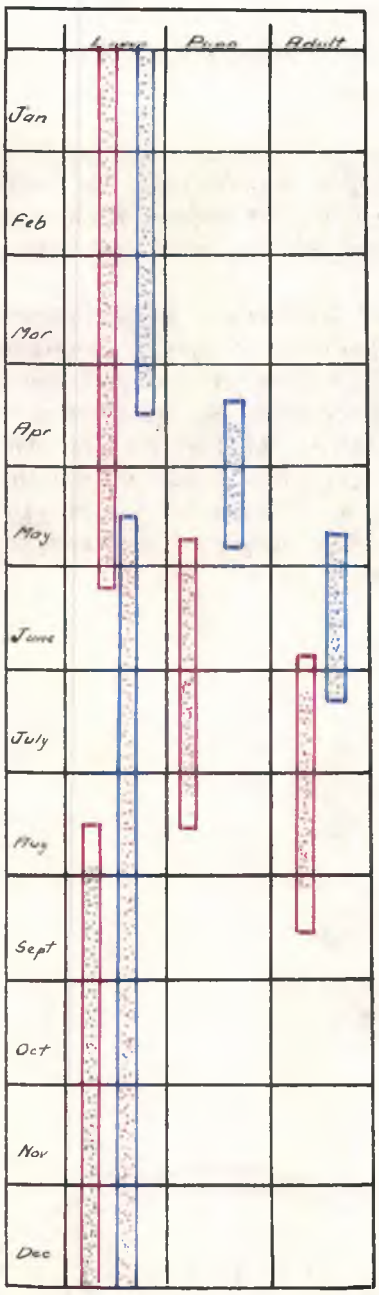
Chart I

The chart on the right represents the probable life history of Coeloides on Dendroctonus monticolae in lodgepole pine at Sula, Montana. The diagram is concerned with only the Coeloides that mature on the beetle larvae within one tree.

Note: The outcome of the brood, after October, of the "early generation" of Coeloides is entirely prophetic. That depicted by the chart has been indicated but not verified.
The egg period is included with the larval period; therefore, the lines beginning the larval stages in the opposite chart represent the first oviposition. Eggs are laid by the main generation of Coeloides up to the pupal stage of D. monticolae; by the early generation until the fall weather becomes too cold to permit active physiological functions.

Chart I

Life History Chart
of
Coeloides
on
Dendroctonus monticolae



Legend

– Main Generation
– Early Generation
⁝⁝ Represents one yr earlier than ⁝⁝

⁝⁝ Represents one yr earlier than ⁝⁝
Same colored stipple represents same yr

Plate I

Fig. 1 - Coeloides egg.
Fig. 2 - Coeloides larva three days old. Ce, head.
Fig. 3 - Coeloides cocoon.
Fig. 4 - Coeloides larva 10 days old. Ce, head.
Fig. 5 - Head capsule of Coeloides larva about same age as Fig. 4. An, antenna; mn, mandibles.

The black line under each figure indicates its actual length.

PLATE I

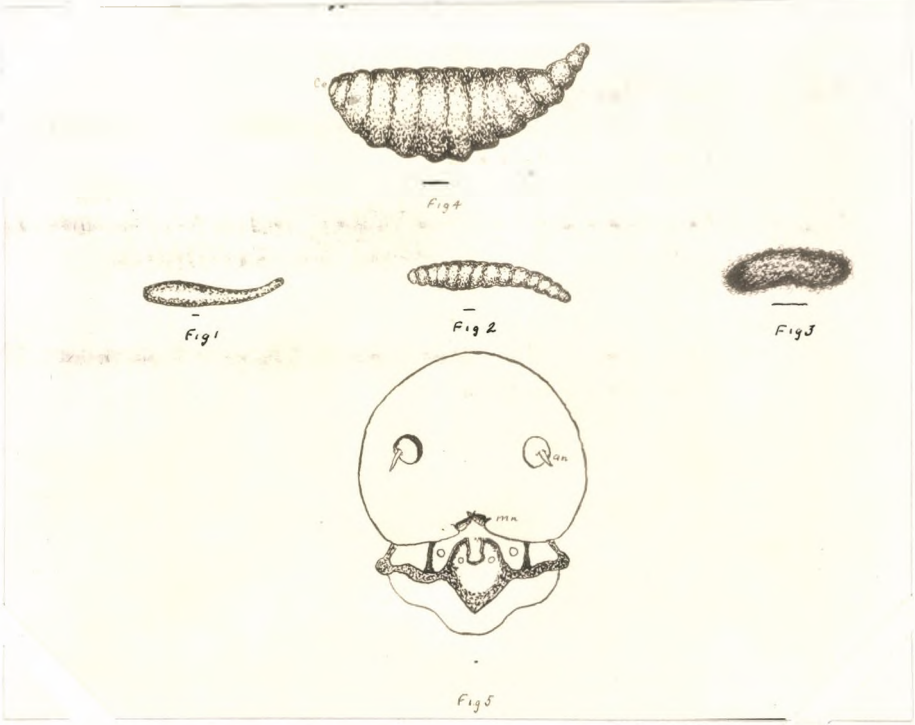


Plate II

Fig. 6 - Adult Coeloides sp. T sh, ovipositor sheath; T, ovipositor. The wings have been cut off. See Fig. 7 for detailed veination.

Fig. 7 - Coeloides sp. st, stigma; 2c, second cubital cell.

PLATE II

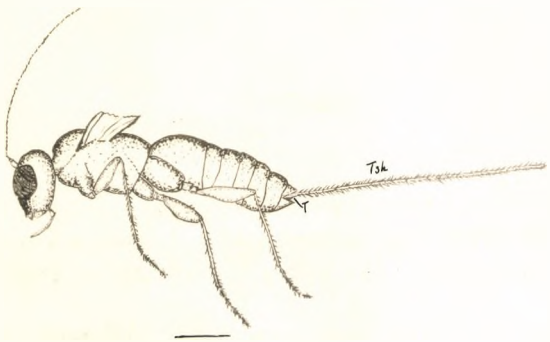


Fig 6

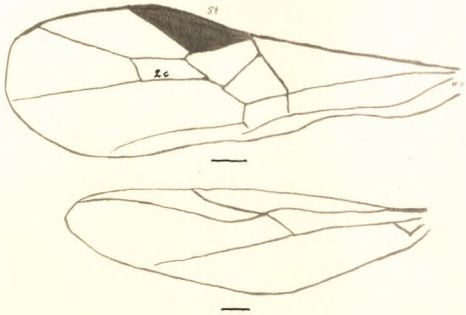


Fig 7

Plate III

Plate III is a photograph of brood of D. monticolae in lodgepole pine. Triangle A points to a Coeloides larva feeding on a beetle larva. Triangle B points to a Medeterus larva.

PLATE III

MEDETERUS sp.

Order Diptera - Family Dolichopodidae

The importance of this species is difficult to estimate, due not only to the fact that its larvae are predacious, and thus probably feed on more than one D. monticolae larva apiece, but also to the fact that they will feed on nearly any larva they chance upon, including their own species. It is believed, however, that they are the first insect of any kind to follow D. monticolae after it attacks a new tree. Since, save for their own species, the beetle larvae are the sole inhabitants of the tree, the predators get in their destructive work early, at a time when the D. monticolae larvae are small and more than one must be preyed upon to furnish sufficient food for development. It may be mentioned here that this condition obtains for but a short period, as Lonchaea viridana Meigen. larvae are very nearly contemporaneous with Medeterus larvae.

Adult

The imago is a sombre grey and averages about 4 mm. in length. By the time the egg galleries of D. monticolae are well advanced the females (Plate V, Fig. 10) have begun to oviposit. Larvae have been collected from trees in which most of the beetle eggs were not yet hatched, or the larvae that were present had not, at most, completed the second instar. Small Medeterus larvae have been collected feeding upon monticolae eggs.

The female fly's actions when searching for a suitable place to lay her eggs are very amusing. Instead of the ordinary fly walk, she appears to glide over the bark surface sidewise and backwards as easily and frequently as forewards, feeling with the tip of her abdomen for small openings, such as places where turning niches and air holes come out under a bark scale, or nearly come through at a crevice. If she, in her explorations, chances upon an entrance or exit hole, it is avoided by hopping away from it. The female apparently shuns such cavities as if "afraid" of falling in, none having ever been observed to enter, though another species of Medeterus, and Lonchaea viridana seems to use these openings exclusively as a means of gaining access to the egg galleries.

Many Medeterus have been observed ovipositing upon trees under natural conditions, but subsequent examination of the spots has never disclosed any eggs, due probably to their small size, protective coloration, and the difficulty in getting the bark scales off evenly. Consequently the number of eggs laid at one time is not known. The act of oviposition usually occupies not longer than 20 to 30 seconds. It thus does not seem reasonable that the number laid at one time would be large; on the contrary one would seem the more credible. Still under confinement two groups of two eggs each and another scattered group of nine were found. The eggs in the former case

were deposited under the edge of the bark square; in the latter case, on the bark surface; whereas in the field no eggs were ever found on the bark surface.

Egg

The egg (Plate IV, Fig. 1), of a brownish-orange cast, and averaging .8 mm. in length and .18 mm. in width, hatches 10 days to two weeks after being laid. The period given is an average for the latter part of August and early September. It may be a shorter period during the warmer season, or a longer one, if the weather is cooler.

Larva

The larva (Plate IV, Fig. 3) on hatching is, except for the mouth parts, a uniform whitish color and but little more than .6 of a mm. in length. Since it has the proportions and other characters of the later instars, it is unmistakable at all times. After eclosion the larva worms its way, by aid of its pseudopods (Plate IV, Fig. 3, ps.) through the cambium, not being confined in its wanderings to the egg galleries nor larval mines. It will feed not only on living larvae it runs across, but dead ones as well, for larvae have been reared from less than 3 mm. in size to nearly 6 mm. (the experiments have not yet been completed) on nothing but dead D. monticolae larvae. Medeterus larvae cannot, nevertheless, be

reared on decaying vegetable matter; this was demonstrated by placing larvae on "sour sap" cambium, as well as cambium tissue from freshly-killed D. monticolae trees. Some of the larvae increased nearly a millimeter, though later shrinking to less than their former size; others showed no mentionable growth, but all died after 5 or 6 weeks. If the experiment shows that the larvae cannot be sustained by cambium tissue, it also shows that the larvae are capable of sustaining themselves a fair period without other nourishment than water. If reared in the laboratory they must be kept in separate phials, for if two or more are placed together there will, after a few days, be but one, and that one fat, sleek, and considerably larger. On one occasion two larvae were observed in "mortal combat", each attempting to feed on the other. Frequently they would come together head-on, with the anterior part of the body in the air, pushing against each other until one gave way. The whole affair was unusual, for commonly when one larva comes upon another, one of them moves off with despatch, and it is only by getting one's mouth parts in first that one is enabled to feed on another. In the above case the larger one conquered and was left peaceably feeding on the smaller, which lost its activity in a surprisingly short time.

Medeterus larvae, it seems, find their prey fortuitously. In the field laboratory they have been observed to pass by D. monticolae larvae and larvae of their own species .1 of a mm. distant, giving no indications of sensing the other's presence. When

one Medeterus larva runs into another of its own species, both of them appear startled and one of them rapidly crawls away. When a beetle larva is bumped into, the predator backs up a bit. If it proceeds ahead again it occasionally passes under the D. monticolae larvae, completely ignoring it; at other times the Dolichopod larva "feels" to the right and left, then passes on, while less frequently it stops to feed. Feeding is done by piercing the cuticle of its host with the lance-like mandibular sclerites (Plate IV, Fig. 8) by which it is enabled to suck out the larval juices. The mechanics of the mouth parts and their structure may best be understood by a study of Plate IV, Figs. 6, 7, and 8.

Under artificial conditions the predators were never observed to consume completely the larva on which they started to feed. Whether it is due, perhaps, to a passing whim, or having had enough nourishment for the time being, they would seldom feed long. In the phial, of course, the partially-consumed larvae would be chanced upon again, fed upon for a while longer until in the end they would be reduced to nothing but their integument. Those that have been fed upon for but a short while bear the same appearance as those "mummified" by Coeloides. This may explain the fact that in the field beetle larvae are found on which neither parasite eggs nor parasite larvae could be found, but which looked embalmed.

Pupa

The predator larvae probably overwinter as such and pupate in the spring. Before pupation they spin delicate cocoons between the wood and bark which at times are closely enough woven to be mistaken, if care is not used, for partially-spun Coeloides cocoons. The pupa (Plate V, Fig. 9) is free and may be easily distinguished from other free pupae by the two long respiratory horns that arise from the dorsal and anterior part of the thoracic region, as well as by the single row of spines on the first seven abdominal segments. (Plate V, Fig. 9 As and Bs). The length of the pupal stage is not known but adults have emerged from pupae 2 to 16 days after collection in the field. The adults may lay their eggs in the same tree from which they emerged, but whether the larvae that emerge from the eggs pupate and transform the same season, or are required to overwinter before pupating, is not known. Medeterus larvae have been collected from trees killed by the mountain pine beetle a year and even two years previously, but it is not believed that some of the flies have two-year life cycles so much as that their larvae, being predacious on many forms of subcortical larvae, occur wherever the adult finds conditions suitable. Larvae have been collected from trees containing mostly species of Ips from tops of lodgepole pine in which sour sap insect larvae were present, and from yellow pine containing D. monticolae brood. Adult Medeterus could be collected any time

in Ips oregoni and D. monticolae trees during August; in September some were collected the last day of the field season (September 17) at Sula; September 23 at Wisdom, Montana. Thus it is seen that the species is very nearly ubiquitous, and may be obtained in all forms, except perhaps the pupa, any time during the field season.

Plate IV.

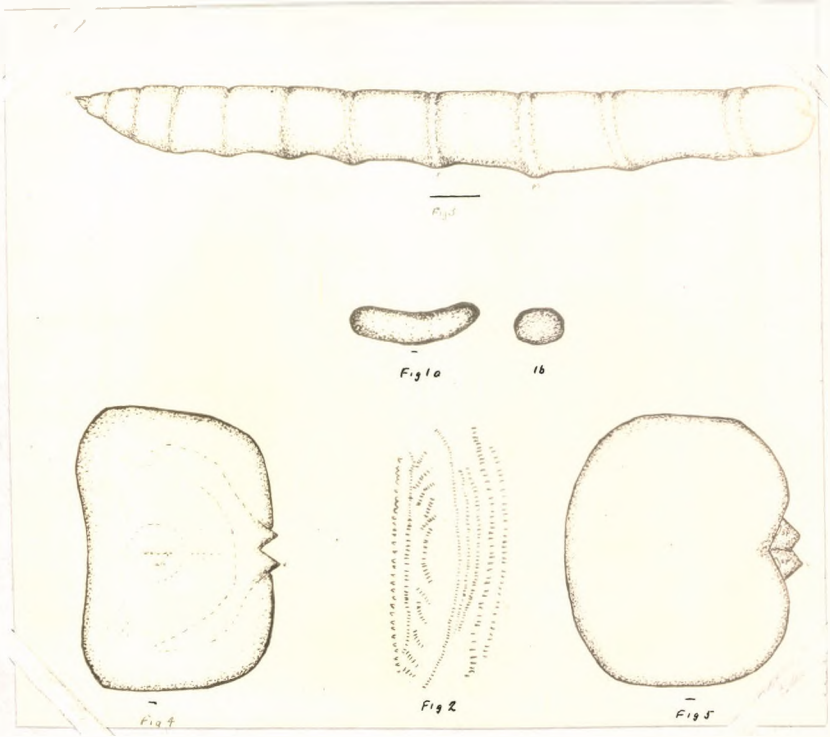
Line below each figure indicates actual size.

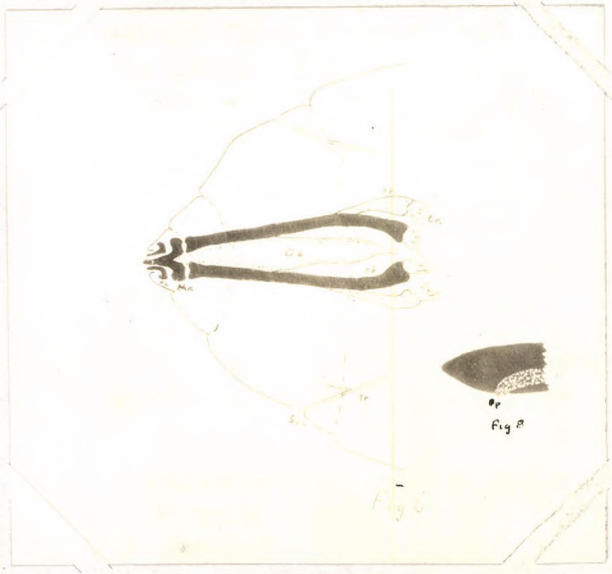
Fig. 1a. Medeterus egg lateral view; b, end view.
Fig. 2. Spicule arrangement on pseudopods of Lonchaea.*
Fig. 3. Medeterus larva about six weeks old. Ce, head; ps, pseudopods; pseudopods are present on all but the last abdominal segment; v, ventral protuberance.
Fig. 4. Terminal segment of above larva. Ventral view. An, anal area.
Fig. 5. Terminal segment of above larva. Dorsal view. Sp, spiracle.
Fig. 6. Ventral view of head of nearly mature Medeterus larva. Ac, accessory sclerite; mn, probably fused mandibular sclerites; oe, oesophagus; sp, supra-pharyngeal sclerite; sb, sub-pharyngeal sclerite; spa, spiracle; tr, trachea; cn, muscle tissue. The larvae are amphipneustic.
Fig. 7. Dorsal view of same larva. Ch, chitinized areas of the first and second thoracic segments; other lettering as in Figure 6.
Fig. 8. Greatly enlarged view of tip of probably fused mandibular sclerites. Bp, buccal papillae.

The mechanics of the mouth parts have not yet been definitely determined, but it is believed that the following explanation is not inaccurate. The extensor muscles force the pharyngeal sclerites against the mandibular sclerite which in turn is forced forward against the host with sufficient force to pierce its cuticula. But as the mandibular sclerite is forced forward it comes in contact with the accessory sclerites, these being united in the head tissues in such a manner that they not only move forward but the tips rotate outwards away from the mandibular sclerite when the main part of the mandibular sclerite is pushed ahead. Since the accessory sclerites are slightly curved they hook themselves against the body walls of the host, thus enabling the predator to maintain better its position.

*Note: Due to error the drawings of the spicule arrangement of Lonchaea and Medeterus larvae were transposed. For spicule arrangement of Medeterus larva see Plate V, Fig. 4.

Plate IV





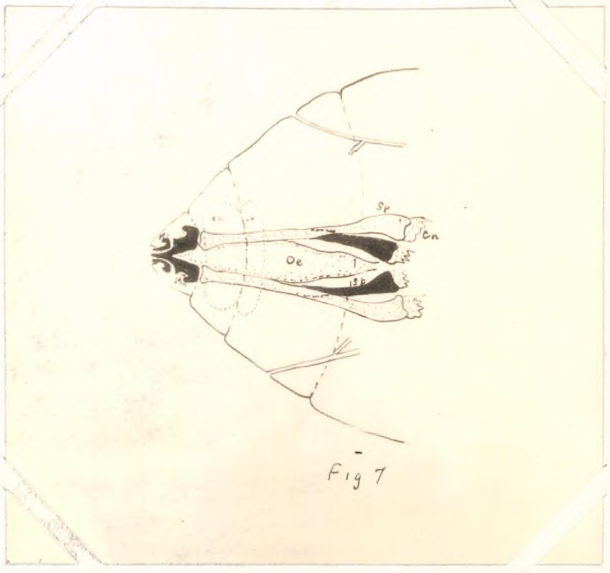


Plate V.

Fig. 9. *Medeterus* pupa. Rs, respiratory horns. As, abdominal spines.

Fig. 10. *Medeterus* adult.

Fig. 11. Wing of smaller and probably different species of *Medeterus*. Note disparity in size.

Fig. 12. Wing of large *Medeterus*.

Plate V

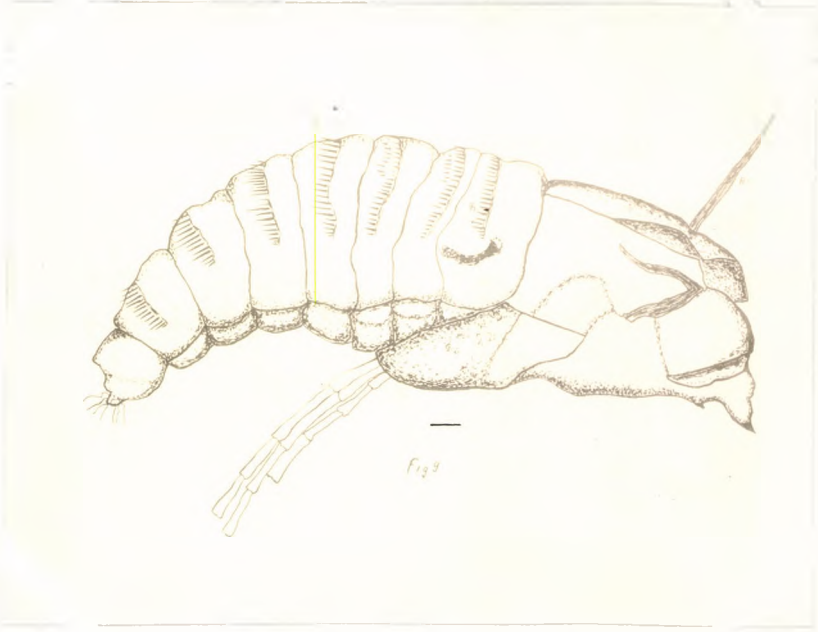


Fig 9

Fig 10

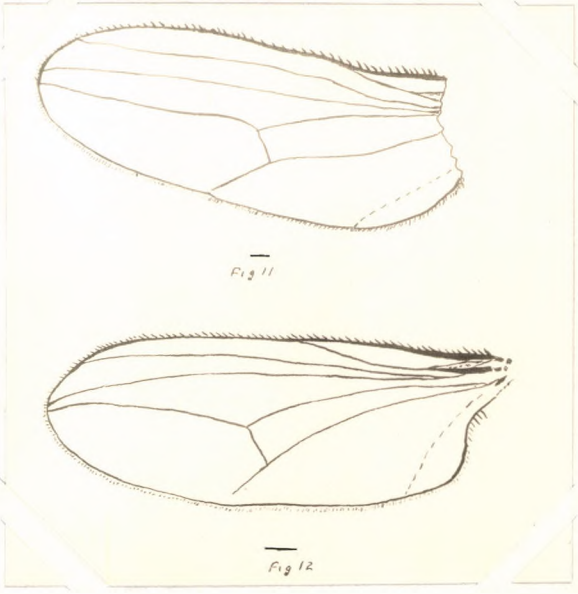


Fig 11

Fig 12

LONCHAEA[1] VIRIDANA Meigen

Order Diptera, Family Lonchaeidae

Though believed at one time to be predacious, experimentation has demonstrated rather conclusively that the larvae of this fly are harmless individuals (in spite of their ferocious-looking mandibles, Plate VI, Fig. 5) which feed only on decaying cambium and dead beetle larvae. The adults lay their eggs not only in D. monticolae-killed trees but Ips oregoni and probably other beetle-infested tops and branches.

Adult

The imago (Plate VII, Fig. 8), about 4 mm. in length and of a metallic blue-green lustre, is found on D. monticolae-infested lodgepole the same season as the attack. The female moves over the bark in a more methodical and business-like manner than Medeterus, and unlike it uses aeration holes and similar openings in which to deposit her eggs. On finding a suitable orifice she either walks beyond it or turns around until the tip of her abdomen can be inserted, then backing in she disappears from sight. The eggs usually are laid in juxtaposition but form a single layer on the inner surface of the bark a short distance from the place of entrance. Two records of different individuals show that in one instance 30 eggs were laid, in the other 36 eggs; in both cases the performance required exactly 9 minutes.

(1) Comstock includes this genus in the Sapromyzidae.

The adult takes to flight in a characteristic eccentric zigzag manner, the burnished chitin glinting in the sunlight like a point of blue flame,- very different indeed than Medeterus which suddenly arrives from nowhere on the bark surface before one to vanish a few seconds later as mysteriously as it appeared. On the other hand, the Coeloides'flight is more prosaic than either of the flies, for it approaches a tree in a more or less direct line with a wing vibration slow enough to be caught by the eye.

Egg

The egg (Plate VI, Fig. 1), a creamy white, hatches 5 to 6 days after being laid. The table below shows the data obtained concerning them.

No. and Place laid	Date laid	Hatched by	Hours	Av. Length	Av. Width
I.o. tree 7	Aug. 6 11:50 AM	Aug. 11 9:35 PM	129¾	—	—
D.m. tree 30	Aug.25 12:56 PM	Aug. 30 8:45 PM	127 1/3	.819 mm	.158 mm.
36	Aug.27 4:41 PM	Sept. 2 11 AM	138 1/3	.773 mm	.18 mm.

Larva

The whitish larvae (Plate VI, Fig. 2) that emerge from the eggs average about 1 mm. in length and .15 mm. in width at the middle, but are wider posteriorly and narrower anteriorly than at the middle; thus

by their shape alone they may be distinguished at all times from Medeterus larvae which superficially they resemble. The formation of the buccopharyngeal armature (Plate VI, Fig. 5), the appearance and position of the caudal spiracles (Plate VI, Fig. 2 Cs) and the arrangement of the spicules (Plate III, Fig. 2) on the pseudopods, are other more specific characters by which it may be distinguished from other dipterous forms. The Lonchaea larva, unlike the Medeterus larva, is not only capable of entirely withdrawing the head within the first thoracic segment, but also of retracting the mandibularsclerites within the head capsule as depicted in Plate VI, Fig. 5. When in motion the larva has a peculiar manner of elevating the anterior part of its body and then slapping it down on the supporting surface. By doing so it apparently forces the mandibular hooks (Plate VI, Fig. 5 Mn) into the tissues, thus enabling it perhaps to pull itself along more easily. The larvae are not confined to the D. monticolae larval galleries, or the region between the wood and bark, but are found more commonly in the inner bark, through which they move with apparent ease.

Further details of the larval history are not known, but it is believed that the larvae overwinter, feed for a short period in the spring, then pupate and emerge in late May and early June. Lonchaea larvae, however, have been collected from trees during September, killed a year previously. Thus it appears that the

females do not confine their ovipositing to newly-killed trees, and the fact that the larvae feed on decaying vegetable matter makes it seem reasonable to expect to find larvae in a D. monticolae-killed tree as long as there is decaying cambium.

Pupa

The pupa (Plate VI, Fig. 3) is coarctate, the indurated skin a reddish-brown, and as the size and shape is that of several other puparia found under the bark of dead lodgepole, care must be taken not to mistake some other species for it.

Plate VI

The line below each figure indicates actual size.

Fig. 1. Two Lonchaea eggs.

Fig. 2. Lonchaea larva about thirty days old. Mn, mandibular sclerites; ps, pseudopods; cs, caudal spiracle; ans, anterior spiracle. Pseudopods are present on the eight abdominal segments.

Fig. 3. Lonchaea puparium. The anterior end faces to the right.

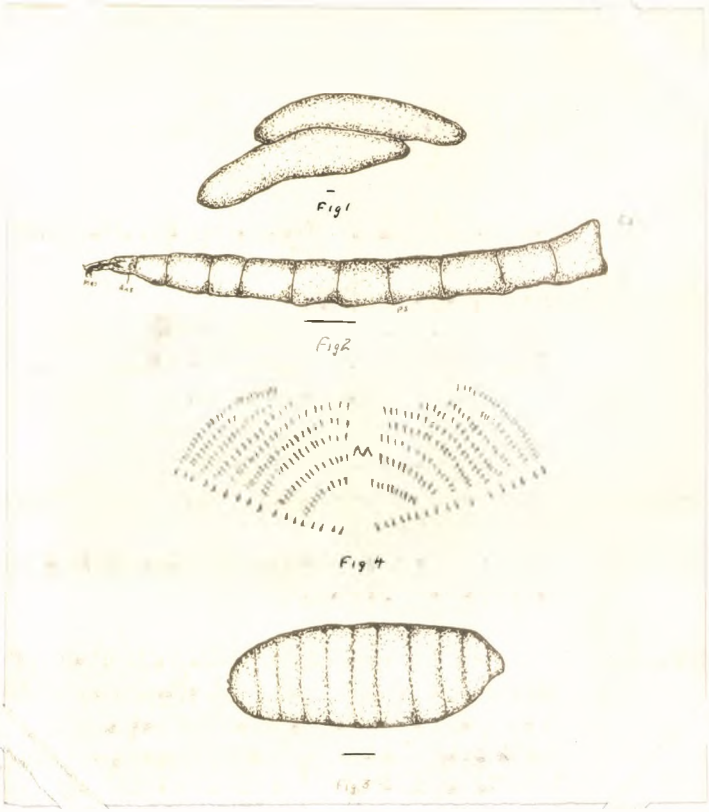
Fig. 4. Spicule arrangement on pseudopods of Medeterus larva.*

Fig. 5. Slightly composite lateral view of larva about 30 days old, showing head first and part of second thoracic segments. An, antenna; l ac s, left accessory sclerite; h, intermediate (hypostomal) sclerite; as, anterior spiracle. (The larva is amphipneustic). rmns, right mandibula sclerite; l mn, left mandibule sclerite; rph, right pharyngeal sclerite; l ph, left pharyngeal sclerite; brp, bridgepiece.

Degree of shading represents degree of chitinization. Regions differentiated by dashed lines represent the right set of the buccolpharyngeal armature which is not visibly united with left set except by the bridge piece, Br p.

* See note, Plate IV.

Plate VI



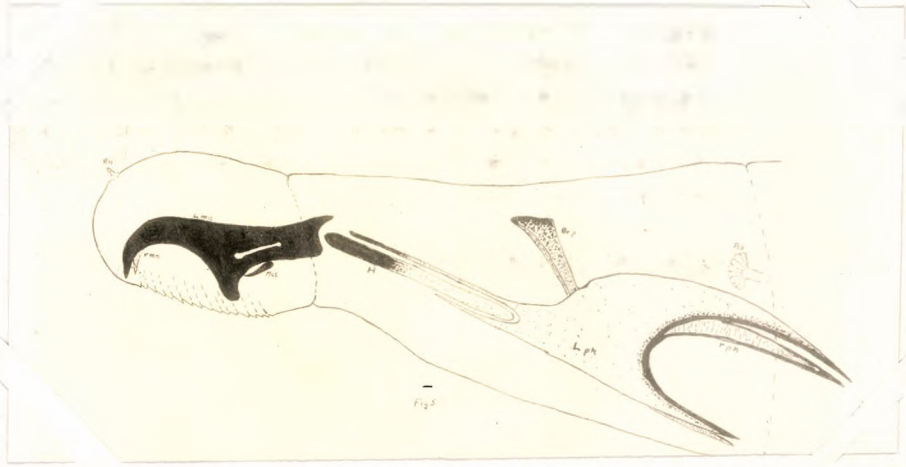


Plate VII

Fig. 8 - Adult Lonchaea viridana Meigen.

Except for Plate III which is an actual photograph, all photographs are of drawings made by DeLeon with the aid of a camera lucida. All the photographs were made by H. J. Rust.

Plate VII

Secondary Insects

The list given here is of secondary insects associated, except for three species, with the mountain pine beetle in lodgepole pine. Those three species are included because in all probability they too will be found allied with it. Under the second column are the dates of the collections made from trees attacked in the 1928 season; the third column, the year previous; the fourth column, the importance of the insect as a predator on the eggs or larvae of D. monticolae. Insects that have been collected from Ips galleries as well are distinguished by an "I" after the date of collection. With the exception of the dates followed by "W", all collections were made at Sula, Montana; the others at Wisdom, Montana.

Insect	Collections from Trees Killed 1928 by D. monticolae	Collections from Trees Killed 1927 by D. monticolae	Value as Controlling Agents of D. m. larva or egg
Order- Coleoptera			
Family- Colydiidae			
Aulonium longum Lec. (Larva)		Sept. 13	Doubtful
Lasconotus confusus Lec.	Aug.20; 25	Aug. 10	"
" pertenuis Csy.	" 27 (I)		-----
" sp.	" 27 (I); Sept.1(I)W	July 3	-----
Family Cucujidae			
Laemophilus angustulus Lec.	Sept. 5 (I)	July 3	Doubtful
Family Nitidulidae			
Epurea linearis Mäkl.	Aug.20,25,26	Aug.10; Sept.18(W)	Doubtful
Larvae of above	Sept. 6	Aug.2; Sept. 6	none to the D.m.larvae
Family- Tenebrionidae			
Hypophloeus paralellus Melsh.	Aug.20,25; Sept.6	Aug. 10	Doubtful
Larva of above		Sept. 13	None to the D.m. larvae
Family- Staphylinidae			
?	Sept. 6		Unknown
Leptusa sp.?	Aug. 25	Aug. 10	Doubtful
Placusa sp.?		Aug. 10	do

Insect	Collections from Trees Killed 1928 by D. monticolae	Collections from Trees Killed 1927 by D. monticolae	Value as Controlling Agents of D. m. larva or egg
Order- Diptera			
Family- Mycetophilidae			
?		Sept. 7, 11	None
Family- Limnobiidae			
Helobia sp.?		Sept. 7	None
Family- Leptidae			
Xylophagus sp.(Larva)		July ?; Aug.10	Attacks D.m. larvae
Family Dolichopodidae			
Medeterus sp.	Aug.18,20,(I) 20(I),21(I)		
Order Hymenoptera			
Family Eurytomidae			
Eurytoma dendroctoni Ashm.	Aug.10(I),13(I),14(I) Aug.20(I);Sept.10(I)	July 16(W), 18(W)	Perhaps hyperparasite. One specimen reared from Coeloides cocoons collected July 3,1928; parasite emerged by August 3, 1928.
Eurytoma sp.	Aug. 9(I)		Unknown
Family?			
Rhopalicus pulchripennis Cwfd.	Aug. 8(I), 13(I) Aug. 16(I); Sept. 6		Uncovered pupa collected from I.c. tree Aug.15, 1928. Emerged by Oct. 5, 1928.
Pachycerus ecoptogasteri Ratz.	July 18(I),Aug.6(I),13(I), 15(I),Aug.23,24(I);Sept.18 (W),20(W).		Unknown
Cecidostiba dendroctoni Ashm.	Aug. 20(I),21, 24(I)		Unknown